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RAIL AND ROAD TRASPORT IN PAKISTAN: COMPETITIVE OR COMPLEMENTARY?

By

Robert E. Looney*

Introduction

To satisfy the need for basic services and demands, to exploit new resources, and stimulate agricultural and industrial productivity and exports, a fully functional, well-placed rail and road network with a hierarchy of linkages is essential. Although infrasturcture is commonly regarded in terms of its physical form--, railroad track, roads, bridges, ports, pipelines and the like--, the real output of infrastruture is a service: efficient movement of people and goods. Thus the efficacy of infrastructure depends not only on the investments made in infrastructure but on the quality of service provided. The contribution of infrastructure to an economy depends not only on the investments made in infrastructure but on the quality of service provided. As discussed in more detail below, in terms of provision of basic infrastructure, Pakistan does not lag behind other countries at a similar level of income and development. However, in terms of quality, reliability and efficiency, Pakistan's infrastructure could critically constrain the country's economic growth as well as improvenents in living standards.

The purpose of this paper is to indentify possible interdependencies between rail and road transport in Pakistan. Are these sectors in competition for traffic and freight or are they complementary in the sense that expanded facilities in one area stimulates follow on activity in the other? Put differently has the country emphasized complimentarity or is a substantial degree of competition encouraged among the various alternative modes?

The historical experiences of develped countries susggest that each of the models noted above has prevailed at one time or another. In North America and Western Europe competition among modes of transport, although constrained by regulation has been relatively free and open. The former Soviet Union and to lesser extent Japan have been

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primarily railway economies with a strong insistence by the authorities that alternative modes not duplicate railway services. Such insistence may well economize transport investment, but inevitably this economy is to some extent at the expense of consumers of transport services[1].

The Issue of Causation

The main questions we want to resolve involve the extent and manner in which road transport competes with rail activity. Specifically, has the expansion of the country's road network been competitive or complementary with increased rail passenger services and/or freight? Do these patterns hold over time or has some shift in the competitive nature of the transport sector changed in recent years? Has the interaction between rail services been the same for both high-type roads and low-type roads and if not what are the unique patterns associated with each?

A key element in assessing these issues involves the issue of causation. If roads and rail are in competition we would expect changes in one to produce a negative impact on the other over time. On the other hand if both systems complement each other an increase in one area of transport should provide a stimulus over time to the other type of service. Clearly then, one must resolve the issue of causation between road and rail activity before any definitive conclusions can be drawn as to the relationshop between these two key modes of transport. Ultimately any statistical test for causation will be based on a number of arbitrary assumptions. Still, using a number of alternative specifications for the key variables it is possible to make some credible inferences concerning the timing of road and rail activities.

The original and most widely used causality test was developed by Granger[2]. According to Granger (using rail and road activity), Rail (RAIL) affects the growth in road activity (ROAD) if this series can be predicted more accurately by past values of rail than by its past rates of growth. To be certain that causality runs from rail to road, the past growth rates in rail must be more accurate than past values of road in predicting increases in rail.

Granger Test

More formally, Granger defines causality such that X Granger causes (G-C) Y if Y can be predicted more accurately in the sense of mean square error, with the use of past values of X than without using past X. Based upon the definition of Granger causality, a simple bivariate autoregressive (AR) model for road activity (ROAD) and rail (RAIL) can be specified as follows:

$$\text{(1)} \quad \text{RAIL}(t) = c + \sum_{i=1}^{p} a(i)\,\text{RAIL}(T-1) + \sum_{j=1}^{q} b(j)\,\text{ROAD}(t-j) + u(t)$$

$$\text{(2)} \quad \text{ROAD}(t) = c + \sum_{i=1}^{r} d(i)\,\text{ROAD}(t-1) + \sum_{i=1}^{s} e(j)\,\text{RAIL}(T-j) + v(t)$$

where ROAD is the growth in the various types of highway transport and RAIL= the growth in railroad activities; p,q, r and s are lengths for each variable in the equation; and u and v are serially uncorrelated white noise residuals. By assuming that error terms (u,v) are "nice" ordinary least squares (OLS) becomes the appropriate estimation method[3].

Within the framework of unrestricted and restricted models, a joint F- test is appropriate for causal detection. Where:

$$\text{(3)} \quad F = \frac{(RSS(r) - RSS(u))/(df(r) - df(u))}{RSS(u)/df(u)}$$

RSS (r) and RSS (u) are the residual sum of squares of restricted and unrestricted models, respectively; and df(r) and df(u) are, respectivly, the degrees of freedom in restricted and unrestricted models.

The Granger test detects causal directions in the following manner: first, Unidirectional causality from ROAD to RAIL if the F-test rejects the null hypothesis that past values of ROAD in equation (1) are insignificantly different from zero and if the F-test cannot reject the null hypothesis that past values of RAIL in equation (2) are insignificantly different from zero. That is, ROAD causes RAIL but DEBT does not cause EXP. Unidirectional causality runs from RAIL TO ROAD if reverse is true. Second, bi-directional causality runs between ROAD and Rail if both F-test statistics reject the null hypotheses in equations (1) and

The results of Granger causality tests depend critically on the choice of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag is greater than the true lag length, the inclusion of irrelevant lags causes estimates to be inefficient. While it is possible to choose lag lengths based on preliminary partial autocorrelation methods, there is no a priori reason to assume lag lengths equal for all types of deficits.

The Hsiao Procedure

To overcome the difficulties noted above, Hsiao[4] developed a systematic method for assigning lags. This method combines Granger Causality and akaike's final prediction error (FPE), the asymptotic) mean square prediction error, to determine the optimum lag for each variable. In a paper examining the problems encountered in choosing lag lengths, Thornton and Batten found Hsiao's method to be superior to both arbitrary lag length selection and several other systematic procedures for determining lag length.

The first step in Hsiao's procedure is to perform a series of autoregressive regressions on the dependent variable. In the first regression, the dependent variable has a lag of one. This increases by one in each succeeding regression. Here, we estimate M regressions of the form:

$$G(t) = a + \sum_{i=1}^{m} b(t-l)\, G(t-l) + e(i) \tag{4}$$

Where the values of m range from 1 to M. For each regression, we compute the FPE in the following manner

$$FPE(m) = \frac{T + m + 1}{T - m - 1} ESS(m)/T \tag{5}$$

Where: T is the sample size, and FPE (m) and ESS (m) are the final prediction error and the sum of squared errors, respectively. The optimal lag length, m*, is the lag length which produces the lowest FPE. Having determind m* additional regressions expand the equation with the lags on the other variable added sequentially in the same manner used to determine m*. Thus we estimate four regressions of the form:

with n ranging from one to four. computing the final prediction error for each regression as;

$$FPE\ (m^*,n) = \frac{T + m^* + n + 1}{T - m^* - n - 1} ESS\ (m^*,n)/T$$

we choose the optimal lag length for D, n* as the lag length which produces the lowest FPE. Using the final prediction error to determine lag length is equivalent to using a series of F tests with variable levels of significance[5].

The first term measures the estimation error and the second term measures the modeling error. The FPE criterion has a certain optimality property that "balances the risk due to bais when a lower order is selected and the risk due to increases in the variance when a higher order is selected[6]." As noted by Judge de.al[7], an intuitive reason for using the FPE criterion is that longer lags increase the first term but decrease the RSS of the second term, and thus the two opposing forces are optimally balanced when their product reaches its minimum.

Depending on the value of the final prediction errors, four cases are possible: (a) ROAD causes RAIL when the prediction error for rail activities decrease when road activities are included in the rail equation. In addition, when rail is added to the road equation the final prediction error should increase. (b) Rail causes Road when the prediction error for expenditures increases when expenditures are added to the regression equation for rail, and is reduced when debt is added to the regression equation for expenditures; (c) Feedback occurs when the final prediction error decreases then rail activities are added to the road equation; and (d) No Relationship exists when the final prediction error increases both when road activities are added to the rail equation and when rail activities are added to the road equation.

Operational Procedues

The data used to carry out the causation tests[8] were transformed into natural logarithms. Next, unit root tests were performed to assure that all series were stationary[9]. Relationships were considered valid if they were statistically significant at the ninety-five percent level of confidence. That is, if ninety-five percent of the time we could conclude that they had not occurred by pure chance, we considered them statistically significant

As noted above, there is no theoretical reason to believe that rail and road activities have a set lag relationship-- that is they impact on one another over a fixed time period. To find the optimal adjustment period of impact, lag structure of up to four years were estimated. The lag structure with the highest level of significance was the one chosen best depict the relationshop under consideration (the optimal lag reported in Tables C- l-- C-6). To test for the stability of relationships, three time periods were examined: (1) the total time period for which data were available (1955 to 1993), (2) post-dissolution with Bangladesh (1972-1993), and (3) predissolution with Bangladesh (1955-1971).

Based on data availability, rail activities consisted of rail infrastructure (kilometer of rail lines) and three measures of rail serives (I) rail passengers, (2) rail freight in tons, and (3) rail freight in tons-kilometer. Road activities consisted of : (1(the length of the total road system (high-type plus low-type roads). (2) high type roads, (3) low-type roads, and (4) road vehicles.

Results

A number of statistically significant patterns were identified by the causation analysis. With regard to the relationship between rail and road infrastructure (Table1:)

- ñ The nation's stock of highway infrastructure (both high and low type roads) exhibited no statistically significant pattern for the period as a whole.
- ñ However, during each of the sub-periods, rail infrastructure appears to impact negatively on road extension. That is, certeris paribus, an increase in rail tracks tends to depress road expansion.
- ñ In the earlier period (1995-71) rail and highway interacted in a feedback mechanism with road expansion tending to result in a follow on expansion in rail tracks. In turn however rail expansion tended to depress further road consturction.
- ñ In the latter period(1972-1993) rail track expansion was no longer positively affected by increased highway penetration. On the other hand the nagetive impact of rail tracks on roads strengthened over the previous period.

- ñ The relationship between rail lines and high-type roads was clearly defined. The dominant pattern was one whereby rail expansion resulted in a subsequent reduction in high type roads. Again, this pattern tended to strengthen over time.
- ñ The most complex railroad/ highway interaction involved the low-type roads. For the period as a whole, expanded rail tended to suppress the development of this type of road.
- ñ However, both sub-periods were characterized by a feedback machanism. Rail tracks again impacted negatively on road expansion during both sub periods, and again this impact strengthened overtime. For its part low-type road expansion during the first period tended to stimulate a further increase in rail tracks. By the most recent period, this impact had turned negative.

Table 1

Pakistan: Interaction of Railroad and Highway Infrastructure, 1995-1993

	Causation Patterns				Dominant
	Rail Rail	Rail Road	Road Road	Road Rail	Pattern
Rail Lines (Kilometers)/ Total Roads-High and Low (kilometers). 1955-1993					
Optimal Lag (year)	1	1	1	1	No
Final prediction Error	(0.22e-4)	(0.23e-4)	(0.66e-3)	(0.68e-3)	Relationship
Rail Lines (Kilometers)/ Total Roads-High and Low (kilometers). 1972-1993					
Optimal Lag(years)	1	3	1	3	RailÛRoad
Final prediction Error	(0.14e-5)	(0.15e-5)	(0.72e-3)	(0.38e-3)	m(-)
Rail Lines (Kilometers)/ Total Roads-High and Low (kilometers). 1955-1971					
Optimal Lag(years)	4	3	1	3	Feedback
Final prediction Error	(0.14e-5)	(0.15e-5)	(0.72e 3)	(0.38e-3)	w(+);w(-)
Rail Lines (kilometers)/High Type Roads (kilometers). 1955-1993					
Optimal Lag (years)	1	1	2	4	RailÛRoad
Final prediction Error	(0.22e-4)	(0.23e-4)	(0.68e 3)	(0.39e-3)	w(-)
Rail Lines (kilometers)/High Type Roads (kilometers). 1972-1993					
Optimal Lag (years)	1	1	1	3	RailÛRoad
Final prediction Error	(0.14e-5)	(0.15e-5)	(0.68e 3)	(0.39e-3)	w(-)
Rail Lines (kilometers)/High Type Roads (kilometers). 1955-1971					
Optimal Lag (years)	4	1	3	1	RailÛRoad
Final prediction Error	(0.90e-3)	(0.99e-34)	(0.69e 3)	(0.29e-3)	w(-)
Rail Lines (kilometers)/High Type Roads (kilometers). 1955-1993					
Optimal Lag (years)	1	1	2	2	RailÛRoad
Final prediction Error	(0.22e-2)	(0.23e-2)	(0.14e 2)	(0.15e-2)	w(-)

Rail Lines (kilometers)/High Type Roads (kilometers), 1972-1993					
Optimal Lag (years)	1	3	1	3	Feedback
Final prediction Error	(0.14e-5)	(0.13e-2)	(0.13e 2)	(0.11e-2)	w(-); w(-)
Rail Lines (kilometers)/High Type Roads (kilometers), 1955-1971					
Optimal Lag (years)	4	3	1	2	Feedback
Final prediction Error	(0.22e-4)	(0.23e-4)	(0.68 3)	(0.39e-3)	w(+); s(-)

Given that the highway sector has expanded retatively to the rail system, these results are somewhat surprising. They suggest that the commonly held view that highway expansion always comes at the expense of rail infrastructure, does not neccessarily hold for Pakistan. While speculative, a possible explanation is that even relatively modest increase in rail tracks puts such a strain on country's resources, that the authorities are forced, during periods of rail expansion, to divert both real and financial resources from the nation's highway program.

The examination of the linkages between rail passengers and the country's road infrastructure also produced several interesting findings more in line with the hypothesis that rail and road transport are competitive rather than mutually supportive. For total roads (Table 2).

ñ The genral pattern was an evolving one whereby during the earlier period (1955-1971) an increased number of rail passengers resulted in a subsequent expansion of the road network.

ñ Over time however a feedback machanism developed whereby expanded roads strongly cut into the number of passengers choosing to travel by rail.

ñ The strength of the negative effect of road expansion on rail passengers was strong enough to carry over to the period as a whole.

ñ Similarly, expanded numbers of rail passengers tended to retard the subsequent expansion in highways. This later effect was not nearly as strong however as the negative link between roads and rail transport.

ñ These patterns also characterized the linkages between rail passengers and high-type roads.

roads have generally had a fairly negative effect on passengers. Again this seems to have strengthened over time, with little interaction between the two during the first period.

Table 2

Pakistan: Interaction of Railroad Freight and Highway Infrastructure, 1955 -1993.

	Causation Patterns				Dominant
	Rail Rail	Rail Road	Road Road	Road Rail	Pattern
Rail Passengers (millions)/ Total Roads(kilometers), 1955-1993					
Optimal Lag (years)	2	4	1	1	RoadÛRail
Final Prediction Error	(0.50e -2)	(0.40e -2)	(0.66e-3)	(0.70e -3)	s(-)
Rail Passengers (millions)/ Total Roads(kilometers), 1972-1993					
Optimal Lag (years)	2	1	1	4	Feedback
Final Prediction Error	(0.75e-2)	(0.51e-2)	(0.72e-3)	(0.64e-3)	s(-) ;w(-)
Rail Passengers (millions)/ Total Roads(kilometers), 1955-1971					
Optimal Lag (years)	3	4	1	3	RailÛRoads
Final Prediction Error	(0.90e-3)	(0.99e-3)	(0.69e-3)	(0.29e-3)	m(+)
Rail Passengers (millions)/ High-Type Roads (kilometers), 1955-1993					
Optimal Lag (years)	2	1	2	4	RoadÛRail
Final Prediction Error	(0.50e-2)	(0.44e-2)	(0.12e-3)	(0.12e-3)	m(-)
Rail Passengers (millions)/ High-Type Roads (kilometers), 1955-1971					
Optimal Lag (years)	2	2	1	1	Feedback
Final Prediction Error	(0.75e-2)	(0.50e-2)	(0.68e-3)	(0.58e-3)	s(-);w(-)
Rail Passenger (millions)/ High-Type Roads(kilometers), 1955-1971					
Optimal Lag (years)	3	1	3	4	RailÛRoads
Final Prediction Error	(0.90e-3)	(0.11e-3)	(0.25e-3)	(0.23e-3)	w(+)
Rail Passengers (millions)/ Low-Type Roads (kilometers), 1955-1993					
Optimal Lag (years)	2	1	2	4	Rail Roads
Final Prediction Error	(0.50e-2)	(0.39-2)	(0.14e-3)	(0.15e-2)	s(-)
Rail Passengers (millions)/ Low-Type Roads (kilometers), 1972-1993					
Optimal Lag (years)	2	1	1	1	RoadsÛRail
Final Prediction Error	(0.75e-2)	(0.48e-2)	(0.13e-2)	(0.15e-2)	s(-)
Rail Passengers (millions)/ Low-Type Roads (kilometers), 1955-1971					
Optimal Lag (years)	2	1	1	1	No
Final Prediction Error	(0.90e-3)	(0.10e-2)	(0.13e-2)	(0.14e-2)	Relationship

These Patterns are consistent with the view that over time road transport in Pakistan has proven an alternative to rail Passengers. This pattern appears to occur independently of the type of road. If anything

During the early years after independence the expansion of rail passengers appears to have placed some pressure on the government to expand connecting roads. Once in place further increases in rail passengers no doubt could be met out by greater utiliztion of excess highway capacity.

For rail freight (Table 3), the dominant pattern was again one whereby expanded highway infrastructure cut into railroad activity:

ñ For the total road system, no clear pattern was observable during the first (1955-1971) period.

ñ However, expanded road distance in the more recent period cut into rail freight. Again, this pattern was strong enough so that it characterized the period as a whole.

ñ In contrast to total roads, high-type roads developed a complex interaction pattern with freight:

ñ While the expansion in high-type roads reduced subsequent rail freight in all of the periods examined, the latest period was characterized by a feedback from rail freight to roads. Specifically, expanded rail traffic provided and added stimulus to expand the nation's high-type road system.

ñ On the other an expansion in the road system (1972-1993) tended to depress subsequent rail freight.

ñ For all of the periods examined, expanded road infrastructure depressed the amount of freight carried by rail. This effect was fairly weak in the early (1955-71) period, but strengthened considerably in the latter period (1972-93).

Table 3

Pakistan: Interaction of Railroad Freight and Highway Infrastructure, 1955-1993.

	Causation Patterns				Dominant
	Rail Rail	Rail Road	Road Road	Road Rail	Pattern
Rail Freight (millions tons)/Total Roads (Kilometers), 1955-1993					
Optimal Lag (years)	1	4	1	1	RoadsÛRail
Rail Freight (millions tons)/Total Roads (Kilometers), 1972-1993					
Optimal Lag (years)	2	4	1	1	RoadsÛRail
Final Prediction Error	(0.66e-2)	(0.50e-3)	(0.72e-3)	(0.77e-3)	m(-)
Rail Freight (millions tons)/Total Roads (Kilometers), 1995-1971					
Optimal Lag (years)	1	1	1	3	No
Final Prediction Error	(0.63e-2)	(0.64e-2)	(0.69e-3)	(0.74e-3)	Relationship
Rail Freight (millions tons)/Total Roads (Kilometers), 1955-1993					
Optimal lag (years)	2	1	2	4	Feedback
Final Prediction Error	(0.76e-2)	(0.58e-2)	(0.12e-3)	(0.11e-2)	s(-);w(+)
Rail Freight (millions tons)/Total Roads (Kilometers), 1972-1993					
Optimal lag * (years)	2	1	1	3	Feedback
Final Prediction Error	(0.66e-2)	(0.55e-2)	(0.68e-3)	(0.42e-2)	s(-);w(+)
Rail Freight (millions tons)/Total Roads (Kilometers), 1955-1971					
Optimal Lag (years)	3	1	3	4	RailÛRoads
Final Prediction Error	(0.63e-2)	(0.49e-2)	(0.25e-3)	(0.29e-2)	w(-)
Rail Freight (millions tons)/Total Roads (Kilometers), 1995-1971					
Optimal Lag (years)	1	4	2	1	Feedback
Final Prediction Error	(0.76e-2)	(0.63e-2)	(0.14e-3)	(0.13e-2)	s(-);w(-)
Rail Freight (millions tons)/Total Roads (Kilometers), 1972-1993					
Optimal Lag (years)	2	4	1	1	RoadsÛRail
Final Prediction Error	(0.66e-2)	(0.48e-2)	(0.13e-3)	(0.15e-2)	m(-)
Rail Freight (millions tons)/Total Roads (Kilometers), 1995-1971					
Optimal Lag (years)	1	3	1	1	FeedsÛRail
Final Prediction Error	(0.63e-2)	(0.39e-2)	(0.14e-3)	(0.15e-3)	m(+)

ñ Another contrast is provided by the low-type road system. In the earlier period, expanded roads provided a fairly strong stimulus to expand rail freight. Over time this stimulus turned negative with increased low-grade roads dampening the future expansion of rail freight.

ñ It is interesting to note that while expanded rail freight has often provided a stimulus to expand the road network, it has provided no such stimulus to the rail network (Table 4).

A pattern somewhat similar to freight was experienced by rail tonnage/distance (Table 5):

ñ For all periods an expansion in total roads, reduced future tonnage/Kilometer services provided by rail. This effect was relatively weak however.

ñ While high-type roads did not cut into rail freight in the earlier period, they had a fairly strong impact in this regard during the

ñ In contrast during the early period, expanded rail freight/distance provided a positive stimulus for the country to extend its high-type road network (again, Table 4, no such effect linked rail services with rail infrastructure).

ñ Expanded low-type roads provided a stimulus to rail freight/distance in the early period. However further expansion in the latter period cut into rail services. Similarly an expansion in rail freight/distance tended to depress the expansion of low-roads.

Table 4

Pakistan: Interaction of Railroad Infrastructure and Rail Services, 1955-1993

	Causation Patterns				Dominant
	Rail Rail	Rail Road	Road Road	Road Rail	Pattern
Rail Lines (Kilometers)/ Rail Passengers (millions), 1955-1993					
Optimal Lag(years)	1	1	2	2	No
Final Prediction Error	(0.22e-4)	(0.32e-4)	(0.50e-2)	(0.51e-)	Relationship
Rail Lines (kilometers)/ Rail Passengers (millions), 1972-1993					
Optimal Lag (years)	1	2	2	2	ServicesÛLine
Final Prediction Error	(0.14e-5)	(0.13-e5)	(0.75e-2)	(0.75e-2)	w(+)
Rail Lines (Kilometers)/ Rail Passengers (millions), 1955-1971					
Optimal Lag (years)	4	1	3	4	Line Services
Final Prediction Error	(0.79e-6)	(0.85-e6)	(0.90e-3)	(0.73e-3)	w(+)
Rail Lines (Kilometer)/ Rail Freight (tons), 1955-1995					
Optimal Lag (years)	1	3	1	4	No
Final Prediction Error	(0.22e-4)	(0.23e-4)	(0.76e-2)	(0.76e-3)	Relationship
Rail Lines (Kilometers)/ Rail Freight (tons), 1972-1993					
Optimal Lag (years)	1	1	2	2	No
Final Prediction Error	(0.14e-5)	(0.15e-5)	(0.66e-2)	(0.67e-2)	Relationship
Rail Lines (Kilometers)/ Rail Freight (tons), 1955-1971					
Optimal Lag (years)	4	1	1	4	LineÛServices
Final Prediction Error	(0.79e-6)	(0.89e-2)	(0.63e-2)	(0.56e-2)	w(-)
Rail Lines (Kilometers)/ Rail Freight (tons), 1955-1993					
Optimal Lag (years)	1	4	1	4	No
Final Prediction Error	(0.22e-4)	(0.66e-4)	(0.66e-2)	(0.69e-2)	Relationship
Rail Lines (Kilometers)/ Rail Freight (tons-Kilometers), 1972-1993					
Optimal Lag (years)	1	1	1	1	No
Final Prediction Error	(0.14e-5)	(0.15e-5)	(0.92e-2)	(0.10e-1)	Relationship

Table 5

Pakistan: Interaction of Railroad Tonnage/Distance and Highway Infrastructure

	Causation Patterns				Dominant
	Rail Rail	Rail Road	Road Road	Road Rail	Pattern
Rail Freight (ton-kilometer)/ Total (Kilometers), 1955-1993					
Optimal Lag (years)	1	1	1	2	Feedback
Final Prediction Error	(0.66e-2)	(0.64e-2)	(0.66e-2)	(0.65e-3)	w(-);w(-)
Rail Freight (ton-kilometer)/ Total Roads (Kilometers), 1972-1993					
Optimal Lag (years)	1	1	1	2	RoadsÛRail
Final Prediction Error	(0.93e-2)	(0.83e-2)	(0.72e-3)	(0.73e-3)	w(-)
Rail Freight (ton-kilometer)/ Total Roads (Kilometers), 1955-1993					
Optimal Lag (years)	1	2	1	1	RailÛRoads
Final Prediction Error	(0.36e-2)	(0.37e-6)	(0.59e-3)	(0.59e-3)	w(-)
Rail Freight (ton-kilometer)/ High type Road (Kilometers), 1995-1993					
Optimal Lag (years)	1	2	2	1	RoadsÛRail
Final Prediction Error	(0.66e-2)	(0.62e-2)	(0.12e-2)	(0.13e-2)	w(-)
Rail Freight (ton-kilometer)/ High type Road (Kilometers), 1955-1993					
Optimal Lag (years)	1	1	1	3	RoadsÛRail
Final Prediction Error	(0.93e-2)	(0.81e-2)	(0.68e-2)	(0.70e-2)	m(-)
Rail Freight (ton-kilometer)/ Low type Road (Kilometers), 1955-1971					
Optimal Lag (years)	1	1	2	2	RoadsÛRail
Final Prediction Error	(0.36e-2)	(0.39e-6)	(0.25e-2)	(0.19e-2)	m(+)
Rail Freight (ton-kilometer)/ Low type Road (Kilometers), 1955-1993					
Optimal Lag (years)	1	1	2	2	RoadsÛRail
Final Prediction Error	(0.66e-2)	(0.85e-2)	(0.14e-2)	(0.14e-2)	w(-)
Rail Freight (ton-kilometer)/ Low type Road (Kilometers), 1973-1993					
Optimal Lag (years)	1	1	1	3	RoadsÛRail
Final Prediction Error	(0.93e-2)	(0.85e-2)	(0.14e-2)	(0.13e-2)	w(-);w(-)
Rail Freight (ton-kilometer)/ Low type Road (Kilometers), 1955-1971					
Optimal Lag (years)	1	2	1	1	RoadsÛRail
Final Prediction Error	(0.36e-2)	(0.27e-2)	(0.14e-2)	(0.16e-2)	m(+)

Road vehicles provided another interesting interaction pattern with rail services (Table 6)

ñ As one might anticipate, an expanded road vehicle fleet cut into rail passenger traffic. This effect was fairly weak in the initial (1955-71) period, however it strengthened over time.

ñ While an expanded number of rail passengers retarded the

ñ Again rail freight was reduced as the number of road vehicles increased. While some competition existed between the two in the earlier period, expanded rail freight had no appreciable impact on the vehicle fleet in the later years.

ñ Finally, increased numbers of road vehicles appear to have stimulated rail's freight/distance services in the early period, but this effect disappeared in more recent times.

Summary

Several general patterns come out of the analysis presented above. With regard to the issue of transport modes competition or complementarity, the picture is mixed (Table 1). In the case of high-type roads and rail tracks, the two types of infrastructure of transport seem to be in competition. The nature of this competition is not clear however- is it for funding of resources or does the trade off come about due to a decline in road usage brought about by an expansion in rail tracks? Given the high cost of track expansion and the declining usage of rail infrastructure, one suspects that competition is in the form of varying budgetary allocations.

Table 6

Pakistan: Interaction of Railroad Activity and Highway Vehicles, 1955-1992

	Causation Patterns				Dominant
	Rail Rail	Rail Road	Road Road	Road Rail	Pattern
Rail Passengers (millions)/ Roads Vehicles (000), 1955-1993					
Optimal Lag (years)	2	1	1	1	Feedback
Final Prediction Error	(0.50e-2)	(0.46e-2)	(0.16e-2)	(0.15e-2)	m(-);w(+)
Rail Passengers (millions)/ Roads Vehicles (000), 1955-1993					
Optimal Lag (years)	2	4	1	1	RoadsÛRail
Final Prediction Error	(0.75e-2)	(0.48e-2)	(0.45e-3)	(0.50e-3)	m(-)
Rail Passengers (millions)/ Roads Vehicles (000), 1955-1993					
Optimal Lag (years)	3	3	1	1	Feedback
Final Prediction Error	(0.90e-3)	(0.63e-2)	(0.35e-2)	(0.27e-2)	m(-);W(-)

Rail Passengers (millions)/ Roads Vehicles (000), 1955-1993					
Optimal Lag (years)	1	1	1	1	RoadsÛRail
Final Prediction Error	(0.76e-2)	(0.66e-2)	(0.16e-2)	(0.17e-2)	m(-)
Rail Passengers (millions)/ Roads Vehicles (000), 1955-1993					
Optimal Lag (years)	2	1	1	1	RoadsÛRail
Final Prediction Error	(0.66e-2)	(0.61e-2)	(0.45e-3)	(0.50e-3)	w(-)
Rail Passengers (millions)/ Roads Vehicles (000), 1955-1993					
Optimal Lag (years)	1	4	1	1	Feedback
Final Prediction Error	(0.63e-2)	(0.47e-2)	(0.34e-2)	(0.28e-2)	m(-);W(+)
Rail Passengers (millions)/ Roads Vehicles (000), 1955-1993					
Optimal Lag (years)	2	1	1	1	No
Final Prediction Error	(0.66e-2)	(0.67e-2)	(0.16e-2)	(0.16e-2)	Relationship
Rail Passengers (millions)/ Roads Vehicles (000), 1972-1993					
Optimal Lag (years)	1	1	1	1	RoadsÛRail
Final Prediction Error	(0.93e-2)	(0.82e-2)	(0.45e-3)	(0.50e-2)	w(-)
Rail Passengers (millions)/ Roads Vehicles (000), 1955-1971					
Optimal Lag (years)	1	1	1	1	RoadsÛRail
Final Prediction Error	(0.36e-2)	(0.31e-2)	(0.35e-2)	(0.40e-2)	w(+)

The competition between rail lines and low-type roads appears different from that of high-type roads. In this case the two types of infrastructure appear to shift one of partial complementarity in the 1955-71 period to one of competition in the 1972-93 interval. That is in the earlier period expanded roads tended to induce a follow on expansion in rail perhaps as more farmers had access from their farms to cities and rail terminals. Again however expanded rail lines tended to retard the subsequent expasion in the low-type road system. In the more recent period expansion of either type of infrastructure appears to have come at the expense of the other.

Rail passenger services (Table 2) appear to currently face competition from both high and low-type roads, although this is a fairly recent phenomenon. In the earlier period increased rail passengers (apparently) placed some pressure on the authorities to expand the High-type roads. Again, this pattern shifted to one of competition in the more recent period with increased rail passengers retarding somewhat the expansion in both types of road infrastructure.

The patterns of interaction between rail freight and the highway system is fairly easy to interpret. In general road expansion has significantly reduced amount of freight carried by the railroads. While there is some evidence of a feedback (both complementary and

The linkages between the road system and rail services as measured by freight distance (Table 5) have varied considerably over time. Initially (1955-71) expanded rail lines also provided a stimulus for enlargement of high-type roads. Similarly the growth of the low-grade road system tended to expand railroad freight/distance. In more recent times this complementarity has turned to one of competition with expanded high-type roads cutting into rail services. A somewhat weaker relationship has developed between rail services and low type roads with an expansion in either dampening the expansion of the other.

One of the more interesting findings was the lack of interaction between rail activity and rail infrastructure (Table 4). For passengers there appear to be two fairly distinct periods. During the earlier (1955-71) period expanded rail lines tended to result in slightly increased volumes of passengers in subsequent years. In more recent years this pattern has changed to one of increased passengers (apparently) putting some pressure to expand rail lines. For freight the pattern was also one in the earlier period of increased lines leading to a subsequent expansion in services. No linkages between freight and rail lines was found for the more recent periods.

Conclusions

From these patterns we can conclude that the country's rail startegy was likely one of unbalanced infrastructure development with an over expansionof capacity in the early years after independence. In part this expansion was response to the new opportunities opening up as a result of the expansion in the road nework increasing accessibility to rail stations.

In more recent times the authorities have allowed the system to equilibrate by letting the volume of services catch up with the stock of rail infrastructure. Given the relatively slow expansion in rail services, there has been little pressure to extend the sector's infrastructure. In large part the slow expansion in rail services stems from the increased competitive position of the highway system.

Many of the factors responsible for the development and expansion of the country's rail system in the 1950s and 1960s have ceased to function. The initial complementarities with the highway system diverting larger and larger volumes of services from the

railroads. Given the high cost of maintaining rail infrastructure the sector's demise should countinue into the foreseeable future.

Notes

1. Edwin T. Haefele ed., Transport and National Goals (Washington, DC: The Brookings Institution, 1969,P.10

2. Cf. C. W.J. Granger, "investigating Causal Relations by Models and Cross-Spectral Methods" Econometrica, vol/37 (1969), PP. 424-38,and C.W.J. Granger "Some Recent Developments in a Concept of Causality" Journal of Econometrics, vol. 39, pp, 199-211.

3. If the disturbances of the model were serially correlated, the OLS estimates could be inefficient, although still unbiased, and would distort the causal relations. The existence of serial correlaion was checked by using a maximum likelihood correlation for the first-order autocorrelation of the residuals [AR (1)]. The comparison of both OLS and AR (1) results indicated that no significant changes appeared in causal directions.. Therefore, we can conclude" roughly" that serial correlation was not serious in this model.

4. C. Hsiao, "Autoregressive Modeling and Money-Income Causality Detection, "Journal of Monetary Economics, vol. 6(1981), pp. 85-106.

5. Since the F statistic is redundant in this instance they are reported here. They are, however, available from the authors upon request.

6. C.Hsaio."Causality Tests in Econometrics, "Journal of Economic Dynamics and Control (1979), P. 326.

7. G.G. Judge, W. Hill. Griffiths, H. Lutheenphol and T.C. Lee, "Introduction to the Theory and Practice of Econometrics" (New York: John Wiley and Sons, 1982).

8. Tests were performed using regression Analysis for time Series RATS 386 Version 4,0 (Doan 1992).

9. Tests were performed using PC Give. See J.A.Dornik and D.F. Hendry, PC Give Version 7.0 "An interactive Econometric

theory and importance of unit roots is outlined in D.A. Dickey and W.A. Fuller "Distribution of the Estimators for Autoregressive Time Series With a Unit Root", Journal of the American Statistical Association, 74 (1979), pp 427-31,and D.A.Dickey and W.A. Fuller "Likelihood Ratio Statistics for autoregressive Time Series with a Unit Root", Econometrica, 49(1981), pp, 1057-72.

10. Notes: Summary of results obtained form Granger Causlity Tests. A Hsiao Procedure was incorporated to determine the optimal lag. All variables are in the form of growth rates. The dominant pattern is that with the lowest final prediction error. The signs (+ -) represent the direction of impact. In the case of feedback the signs refer to the second and fourth set of causation patterns (i.e., rail/road and road/rail). Each of the variables was regressed with 1,2,3, and 4, year lags. Strength assessment (s= Strong; m =moderate; w = weak) based on the size of the standardised regression coefficient. All data is from: government of Pakistan, Economic Survey 1993-94 (Islamabad, 1994).